NASA SBIR/STTR Technologies

High-Fidelity Gas and Granular Flow Physics Models for Rocket Exhaust Interaction with Lunar Soil

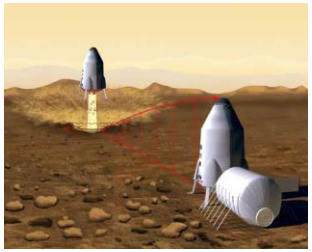
PI: Peter Liever, CFDRC, Huntsville, AL

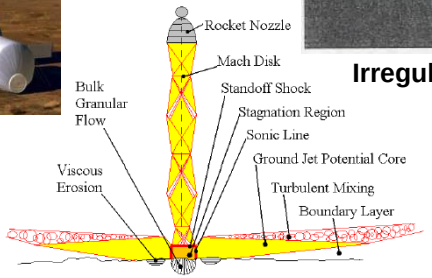
Proposal No.: T7.01-9911

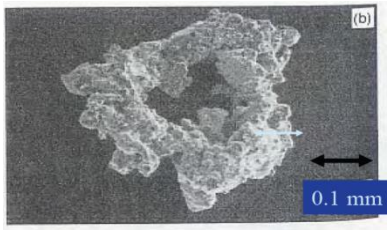
Identification and Significance of Innovation

- Current models of lunar soil erosion and transport ignore essential physics peculiar to lunar environment:
  - Rarefied plume surface layer flow; wake/turbulence effects from surface obstacles; lift from collisions in high particle loading
  - Drag/lift of highly irregular grain shapes in mixed rarefied flow
  - Granular stress models entirely based on empiricism for mono-dispersed spherical particles; ignore shape and size mix
- Reduce erosion modeling uncertainties by deriving first principle physics sub-models applicable in lunar flow environment

Expected TRL Range at the End of Contract (1-9): 4







Irregular Lunar Soil Grain

Technical Objectives

- Apply innovative concepts/tools for rarefied flow, irregular grain shape particle aerodynamics, collision effects, granular stresses

Work Plan

- Establish irregular particle interaction mechanics models from first principle Lagrangian DEM particle interaction models and formulate accurate constituent models
- Implement the irregular shaped granular flow mechanics physics models in an Eulerian granular flow model based on particle kinetic formulations
- Implement the Eulerian granular flow model in multi-phase Eulerian simulation system coupled with the exiting UFS continuum-rarefied flow solver framework
- Perform detailed verification and validation of the integrated simulation tool against experiments with sand, lunar simulants and Martian simulants under earth and reduced gravity conditions

NASA and Non-NASA Applications

- Robotic and manned Moon landing
- Robotic and manned Mars landing
- Dust generation environment during ISRU operations (rovers, excavation, mining, etc.)
- Brown-out during desert helicopter and aircraft take-off

Firm Contacts

- CFDRC: Dr. Peter A. Liever
  (256) 726-4930 *pal@cfdrc.com*
- STTR Partner: Prof. Jennifer S. Curtis
  Chem. Eng. Dept., University of Florida
  (352) 846-1982 *jcurtis@che.ufl.edu*